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Estimating Returns from Past Investments into Beef Cattle Genetics RD&E in Australia

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Abstract

This study aimed at estimating the costs and benefits of all beef cattle genetic improvement activity, across Australia, over the period 1970 to the present. The total cumulative Present Value (PV) of investments by industry, government and other agencies into selection, crossbreeding and grading up since 1963, and of imported genetics, was estimated to be \$340m (in \$2001 at a 7% discount rate). Using a suite of genetic evaluation models, farming systems models and an industry-level model, the cumulative PV of industry returns were estimated. Within-breed selection generated \$944m; crossbreeding in southern Australia \$255m; changing breed composition in southern Australia \$62m; and changing breed composition in northern Australia \$8.1bn. The benefit/cost ratio for this investment was 28:1 over the last 30 years.

Keywords

Beef, genetics, benefit cost analysis

1. Introduction

The Australian community has for several decades now made investments aimed at improving productivity and profitability in beef cattle through genetic technologies. Genetics RD&E is defined to include all areas of breed manipulation, such as importation of new genetic material, cross-breeding for hybrid vigour, within-breed selection, and changing breed composition to provide cattle more suitable for particular markets or particular environmental conditions. Investments into these technologies have included research and development programs, extension programs and importation.

Meat and Livestock Australia (MLA) recently commissioned an economic analysis of the return on investment from genetic technologies for the Australian beef industry. The study aimed at estimating the costs and benefits of all beef cattle genetic improvement activity, across Australia, with a focus on the period 1970 to the present. Here, we briefly report on that study.

2. Investment into research, development, implementation/extension and importation

Investors into beef cattle genetics were invited to provide data on the level of their investment (both cash and in-kind). Investments included measurement and recording costs, genetic evaluation charges, and importation costs carried by breeders, together with research and extension projects conducted by a range of organizations. As far as possible, total community costs were estimated.

The total cumulative Present Value (PV) of investments to 2001 by industry, government and other agencies into selection, crossbreeding and grading up since 1963 was estimated to be \$310m (in \$2001 at a 7% discount rate). These investments were made by state government agencies (Departments of Agriculture) (50%), by MLA and its predecessors (25%), by Breed Societies (16%) and by federally-funded agencies such as CSIRO and the Beef CRC (9%). The split between research and extension was not provided by a number of agencies, so that separate returns to these activities could not be calculated.

Most cattle breeds in Australia regularly access overseas gene pools of their respective breeds, particularly the large North American populations. Because many of the Australian progeny of these animals enter genetic evaluation, it is possible to estimate the value of the genes of the imported animals. This value is included in the genetic trends used to calculate cost-of-production changes (see below).

The cost of importation was harder to estimate, because no organization maintains records of importation that distinguish beef from dairy. However, based on information from

AQIS (Australian Quarantine Inspection Service), from breed societies and from semen sellers, importation costs were estimated to total approximately \$27m in cumulative PV.

This total investment of around \$340m represents an average annual investment in PV terms of around \$8m (for the period 1963 to present). The level of investment is estimated to have peaked in 1985 at around \$19m, the year that the BREEDPLAN evaluation system was introduced. Using a conservative estimate of annual gross income for the industry of \$3.5bn, the total annual investment into genetic improvement research, development and extension represents about 0.25% of annual income.

3. Overall approach to estimating benefits

The broad approach taken was to derive genetic trend data over time from genetics evaluation software packages, for each of the major production system x target market combinations used in producing beef in Australia; then to convert these trends in physical animal characteristics into changes in cost of production using representative gross margin budget models; simulate the impact of the various cost of production reductions using an industry economic model; and aggregate the benefits across all of the combinations of production system and target market of interest.

Four avenues to improved returns were evaluated: from within-breed selection in the major breeds, from cross-breeding in the temperate herd, from changes in breed composition of southern herds towards breeds which command market premiums for particular markets, and from the infusion of *Bos indicus* genetic material into sub-tropical and tropical northern Australia.

3.1 Cattle evaluations, indexes and genetic trends

Information on registrations was derived from the registered breed societies, but this is not the same as evaluations, and is likely to overestimate evaluations. Information on

evaluations by sire and breed is presented for certain breeds based on the BREEDPLAN database.

Genetic trends were derived from BREEDPLAN EBV information for seedstock animals within breeds. The BreedObject software was used to translate these numbers into seedstock EBVs for commercial herd traits (Barwick *et al.* 2001). Averages of these by year of birth of seedstock bull were used to measure genetic change (or trends). Genetic change was assumed to occur in the commercial sector at the same rate as in the seedstock sector, but lagged by 5 years for herds using BREEDPLAN bulls, and lagged by 10 years for those using non-BREEDPLAN bulls.

Genetic trends in index traits were calculated for sale liveweight (kg), dressing percentage (%), carcass meat percentage (%), fat depth (mm), cow weaning rate (%), marbling score, cow survival rate (%), cow liveweight (kg) and calving ease (%). The predicted trait trends at 5-year intervals from 1985 to 2005 for the main breed x market combinations were assessed. Significant genetic trends were only observed for progeny liveweight and cow weight. Other trait trends were either not statistically different from zero or not significant enough to include in farm-level budgets. As there was no capacity to measure feed conversion efficiency in the database used, no improvements in feed conversion ratio to offset larger cattle sizes were included.

3.2 Aggregation

Estimates were made of the proportions of the beef cattle population according to bull breed, cow type, market orientation (domestic or export) and market type (eg supermarket). Aggregate benefits were derived using these proportions to weight the benefits estimated from trait trends. These 36 detailed breed x market classifications were represented by six representative "cases", termed domestic high recording, domestic moderate recording, export high recording, export moderate recording, European and northern. The genetic trends and the

herd x market case proportions were used to assess potential gains from selection and crossbreeding.

3.3 Farming system budgets

The genetic trend impacts were incorporated into Gross Margin budgets (NSW Agriculture 2001) for the six market x production system cases to calculate changes in variable costs. Extra feed costs associated with the larger animals were calculated using the BEEF-N-OMICS model (NSW Agriculture and Meat Research Corporation 1991) together with estimates of improved pasture costs and stocking rates. Because no information was available on feed conversion efficiency gains, the extra costs of larger animals eating more feed have to be included.

Table 1. Cumulative annual percentage point reductions in per unit variable costs

5-year period to	1984	1989	1994	1999	2004
Domestic high recording	0	0.5	1.7	2.9	4.8
Export high recording	0	0	0	0.6	1.2
Domestic moderate recording	0	0	0.8	1.6	2.6
Export moderate recording	0	0	0.6	0.6	0.6
European	0	0	0.9	0.9	2.1
Northern	0	0	1.1	1.6	2.3
Crossbreeding (south)	3.0	3.0	3.0	3.0	3.0

3.4 Estimating economic returns

To estimate industry and community returns from beef cattle genetic improvement activity, an Equilibrium Displacement Model (EDM) of the Australian beef industry was used (Zhao 2000). This approach is widely used in economic evaluations of technologies in

agricultural and other systems (Alston, Norton and Pardey 1995). The model has a horizontal and vertical representation of all the relevant industry sectors. It incorporates prices and quantities, and supply and demand elasticities, so that any interactions within and between sectors are represented. The model is based on actual data for the Australian beef industry.

This framework represents technological change as a percentage change in variable costs per unit of output, which is interpreted within the model as influencing the supply of beef product. Previous results from this economic model (Zhao *et al.* 2001) showed that a 1% reduction in variable costs (shift in supply) at the farm level results in a \$30 million change in economic surplus (to the whole industry) in \$2001. These analyses have also shown that up to 33% of gains from technologies accrue to farmers (weaner producers, grass finishers and backgrounders), and domestic consumers receive 50% or more of the gains.

4. Results

4.1 Within-breed selection

Genetic trends in cost-of-production were then aggregated using estimates of the proportions of cattle from each production system x target market combination, the proportions of animals that have been evaluated through BREEDPLAN, and the estimated genetic lag between evaluated and non-evaluated cattle.

Inputs into the EDM were estimated at successive 5-year intervals (Table 1), so that the cumulative effects of selection could be modelled. Also, the full benefit flow from all genetic change that has occurred to date (but not all of which has yet flowed through the commercial population) was included (out to 2005 for BREEDPLAN-measured bulls and out to 2010 for non-BREEDPLAN-measured bulls).

Using this approach, the cumulative PV of industry returns from within-breed selection is estimated at \$944m. Of this, one-third or \$315m is estimated to have accrued to farmers.

4.2 Crossbreeding in southern Australia

Crossbreeding, whether through use of crossbred cows, or more simply by using a different breed of bull, delivers benefits from heterosis and/or breed complementarity, which impact on cost-of-production. The gross margin impact of these crossbreeding systems was estimated for a range of southern production system x target market combinations, based on previous crossbreeding research projects (Barlow *et al.* 1989, Parnell *et al.* 1992). ABARE (Australian Bureau of Agricultural and Resource Economics) statistics provide data on the proportion of cattle in southern Australia that are crossbred. This has risen from very low levels in 1970 to around 40% in 2000. From these data, and again using the EDM, the benefit from crossbreeding in southern Australia is estimated at \$255m to the industry in PV terms, or \$85m on-farm.

4.3 Changing breed mix in southern Australia

During the 1990s there was a significant shift in breed composition of the southern herd, with producers increasing their use of Angus and Angus-cross cattle in response to market premiums for particular markets. These premiums mean that there are on-farm and community benefits from this breed change, even though improvements in carcase characteristics were not evident in the genetic trend data used.

The benefits were estimated assuming that the proportion of the southern herd that is Angus or Angus-influenced has risen from 9.5% to 22% since 1990, and that the premium per animal slaughtered is \$25 (P. Parnell, pers comm, February 2002). This value was compared to the budget values of Angus cattle finished from the major production systems evaluated (Angus supermarket and Angus B3 Japanese steer) (NSW Agriculture 2001), resulting in proportionate premiums of 3.5% and 2.1% respectively. These premiums were modelled in the EDM framework as increased willingness to pay by consumers of the beef produced by these types of cattle.

Using these values, the industry benefit from changing breed composition during the 1990s in southern Australia was estimated to be \$62m. This translates to a benefit at the farm level of some \$21m.

Other longer-term changes in breed composition in the southern herd were not evaluated, primarily due to lack of data. Crossing with European breeds in Australia is also certain to have had some impact, although their proportion of the seedstock sector remains modest (Sillar *et al.* 2001).

4.4 Changing breed mix in northern Australia

Since 1950 (but especially since about 1970) there has been a steady increase in the proportion of cattle in northern Australia that are *Bos indicus* or *Bos indicus*-infused. This has been principally through use of Brahman cattle and their derivatives, and has been a response to the superior adaptation of *Bos indicus* in the harsh production environments of northern Australia. Unfortunately, it was not possible to reliably calculate cost of production changes for this impact. To estimate the benefits flowing from this infusion, a different method was used. It was assumed that the proportion of *Bos indicus* has risen from 5% in 1970 to approximately 85% during the 1990's (ABARE data) and that the improved profit resulting from replacing a British breed cow with an *indicus* cow was \$87 per adult equivalent per year. This estimate derives from simulations of representative *Bos taurus* and *Bos indicus* herds with the BREEDCOW software package (Holmes 2002).

From these values, and data on the numbers of cattle in the northern herd (ABARE), the cumulative NPV of infusing *indicus* genes was estimated to be approximately \$8.1bn since 1970. This analysis proxies genetic changes in fertility and adaptability that were not included in the BREEDPLAN data.

5. Conclusions

One conclusion is that the estimated returns on past investments in beef cattle genetics R&D in Australia have been very healthy. Over all sources, the total return to the Australian beef industry from genetic technologies since 1970 was estimated to be \$9.4bn against a total investment estimated at \$340m. The benefit/cost ratio for this investment is 28:1 over the last 30 years. Based on previous work which shows that cattle producers gain about one-third of the total benefits, it can be estimated that cattle producers are likely to have benefited by over \$3bn from these past investments. The on-farm benefits represent an extra \$2,500 in PV terms for each of the approximately 40,000 specialist and non-specialist cattle producers in Australia in each of the last 30 years.

The biggest contribution to this high benefit/cost ratio has been the infusion of better-adapted *Bos indicus* genetic material into the sub-tropical and tropical herd, and as noted above, a less reliable method was used to estimate these benefits. But even if these benefits are ignored, and all costs are attributed to the other sources of value (within-breed selection, southern crossbreeding and changing breed mix in the south), beef genetics RD&E has generated a NPV of \$921 million, a Benefit Cost Ratio of 3.7:1 and an Internal Rate of Return of over 19%. Applying the shares of benefits noted above, beef producers are likely to have benefited by about \$307 million and domestic consumers by about \$460 million, from past investments in beef cattle selection and crossbreeding R&D and the development of premium markets for higher quality beef.

The second conclusion is that these results seem to be in the ballpark of other estimates from similar studies. Parnell *et al.* (1992) estimated that the NSW Agriculture Grafton beef cattle cross-breeding program would yield a NPV of benefits of approximately \$170 million by 2020, a BCR of 8.5:1 and an IRR of 13.5%. Corresponding figures for the Trangie/Glen Innes program were \$170 million, 3.2:1 and 13.5%. These rates of return match those found for selection and crossbreeding in the current study. In South Africa, Mokoena *et*

al. (1999) recently estimated the return on investments in beef cattle performance testing. They found IRRs between 29-44%, compared to IRRs between 19-22% for all animal improvement schemes. Again, these estimates are similar to those found in this study. More generally, Alston *et al.* (2000) have recently reviewed almost 300 studies of R&D in agriculture which provided more than 1800 estimates of rates of return from 1958 to 1998. The rate of return across all studies (some outliers excluded) ranged from -100 to +910. The average was 65. The rate of return for livestock-only studies was not significantly different from this average, but that for research and extension together (47) was significantly less than for research-only studies.

The third conclusion is that all sectors of the beef industry, including feedlots, processors, marketers and consumers, benefit from genetic improvement implemented at the farm level, not just producers. In particular, domestic consumers receive about half of the total benefits from RD&E in the Australian beef industry, from having access to greater quantities of beef at lower prices. The links between who pays for beef industry RD&E in Australia, and who gains from the results of this RD&E, are explored in detail in Zhao *et al.* (2002).

However, while past investments into beef cattle genetic improvement in Australia via RD&E, genetic evaluation and importation have been highly profitable, current rates of growth of the benefits are much closer to the total annual investment. In particular, the huge benefits from the infusion of *Bos indicus* genes through the northern Australia herd are all in the past.

On the other hand, it is known that there is much scope to achieve much faster rates of genetic gain. The cumulative nature of genetic gain means that many of the benefits (of within-breed selection in particular) will continue into the future, and are expected to grow. In addition, more recent genetic trend data indicates that some of the carcass quality traits such

as retail yield and marbling are starting to show significant increases, and there are new gene marker technologies being developed which should enable faster adoption of improved genetics.

The real challenge for the industry, and all its components is now to ensure that the infrastructure of knowledge, tools and technologies for genetic improvement is used as effectively as possible to achieve faster rates of genetic gain coupled for profit, coupled with making best use of the range of breeds and crosses available.

The results of this analysis are being used by MLA and industry to develop strategies for beef cattle genetics RD&E over the next 5 years.

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